Central Yavapai Highlands Water Resources Management Study
Environmental Considerations related to Water Supply Alternatives

This document contains a brief description followed by an environmental-issues table for each alternative under consideration for meeting future unmet water demands in the CYHWRMS study area. The table contains hydrologic, biologic, and watershed categories. The effect on these categories is classified as positive (+), negative (-), or neutral (0). A notes column provides some explanation of the rationale for effect.

This environmental considerations analysis will be assessing environmental issues and impacts within the study area only. Water development outside the study area would require additional environmental assessment relative to impacts to those areas where water is derived from, including ground water and/or surface water sources.

Alternative 1
Local Groundwater Development (within each WPA)

This alternative proposes the continued use and development of groundwater supplies within each of the water planning areas to meet all of their future municipal water demand.

For municipal demand, each Water Planning Area (WPA) was analyzed to determine what percentage is provided by a water provider or by private domestic wells. It is presumed that groundwater in rural areas is generally accessed by private domestic wells (exempt wells). Urban areas are generally served by water providers of varying sizes with non-exempt wells. The proportion of non-exempt wells and exempt wells reflect an approximation of rural and urban populations in each planning area. It is assumed that the present pattern for rural or urban areas will be similar in future growth.

Local groundwater development in the Prescott AMA will be more limited than in the rest of the study area. State law prohibits future subdivision growth based on local groundwater development, although growth will likely continue on a limited number of subdivision lots that were platted prior to the 1999 Groundwater Mining Declaration and on lot-splits supplied by exempt wells.

Alternative 1. Local Groundwater Development (within each WPA)

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	**0/-**	Diminished flow reduces mixing and oxygen levels which affects fish and aquatic species. Possible site specific consideration to quality parameters,

		including temperature.
Impact to Streamflow	-	Eventual reduction of base flow where there is a GW-SW connection
Impact to Groundwater Availability	-	Lowers water table, reduces amount of recoverable groundwater in areas of pumping
Biologic		
Impact to Vegetation	-	Eventual reduction of riparian habitat, and may include other vegetative communities (phreatophytes).
Impact to Wildlife (Riparian-Obligate)	-	Habitat loss to riparian species
Impact to Fish/Aquatic Species	-	Habitat loss to aquatic species from changes in base-flow, stream flow magnitude, duration and flooding events
Watershed		
Impact to Watersheds	0	Potential increase in ephemeral & intermittent stream segments. Land subsidence (minimal)

Alternative 2
Regional Groundwater Development within the Study Area – Big Chino Sub-basin Pipelines to Prescott AMA and Verde Valley

This alternative considers regional groundwater development for the Prescott AMA, specifically the Prescott Valley, Chino Valley and Prescott WPAs from the Big Chino Sub-basin. A second alternative considers regional groundwater development for the Verde Valley, specifically the Clarkdale, Cottonwood, Sedona, Big Park, Lake Montezuma and Cottonwood-Verde Village WPAs from the Big Chino Sub-basin.

The Prescott AMA alternative provides water to the planning area based on Arizona legislation ARS Sec. 45-555. The total volume of water described in ARS Sec. 45-555(E) allows a city or town in the Prescott AMA to withdraw and transport 8,068 AF/YR from the Big Chino sub-basin. Additionally, Chino Valley has requested that 4,400 AF/YR be included in this alternative. Therefore, for the purposes of groundwater development for the Prescott AMA, 12,468 AF/YR of groundwater was used for this alternative. Since Prescott has purchased a 4,500-acre property 18 miles northwest of Paulden (The Big Chino Water Ranch) for purposes of locating a well field, it is assumed that the well field would be located at the Water Ranch.

The second alternative for the Verde Valley was considered since the alternatives needed to address the future water supply needs of all the WPAs and not only for the ones that applied for legislative authority. Therefore, for the purposes of groundwater development for the Verde Valley, 12,382 AF/YR of groundwater was used for this alternative. It is also assumed that the well field would be located at the Big Chino Water Ranch.

Alternative 2. Regional Groundwater Development within the Study Area

Environmental Issues (+) or (-) Affect, or Minimal (0)	Assumes Mitigation* for Maintaining Base flow	Assumes NO Mitigation and Pumping Impacts Stream	Notes
Hydrologic			
Impact to Water Quality	0/-	-	Diminished flow reduces mixing and oxygen levels which affects fish and aquatic species. In lieu mitigation water may be of lower quality than GW supported springs.
Impact to Streamflow	0	-	Eventual reduction of base flow where there is a GW-SW connection
Impact to Groundwater Availability	-	-	Within the sub-basin where pumping occurs, and down-gradient sub-basin if GW underflow exists.
Biologic			

Impact to Vegetation	**0**	**-**	Reductions in GW may affect SW flows, and eventual reduction of riparian habitat, and may include other vegetative communities (phreatophytes).
Impact to Wildlife (Riparian-Obligate)	**0**	**-**	Negative effects with loss of riparian vegetation
Impact to Fish/Aquatic Species	**0/-**	**-**	Habitat loss to aquatic species from changes in base-flow, stream flow magnitude, duration and flooding events Also depends if mitigation impacts water quality. Mitigated water supplies may include water of lower quality than what is being lost (replaced).
Watershed			
Impact to Watersheds	**0**	**0**	Impact dependent on level/type of mitigation. Positive or negative effects are very difficult to discern at this level. Expect benefits to basin where water is transported; sustains groundwater contribution to streams, helps reach safe-yield, provides alternative to exempt wells.

* Mitigation is based on <u>An Agreement in Principle</u> among the City of Prescott, the Town of Prescott Valley, and the Salt River Valley Water Users' Association and the Salt River Project Agricultural Improvement and Power District. The agreement is titled: *Withdrawal and Use of Water from the Big Chino Sub-Basin and the Protection of Stream Flow in the Upper Verde River.*

The Communities agree that in the event the withdrawal of water from the Big Chino Sub-Basin is negatively affecting the minimum flow of water in the Upper Verde River, they will mitigate such impact proportionately to the extent of the effect of their combined withdrawals on the Upper Verde River as compared to the effect of the withdrawals by other water users in the Big Chino aquifer.

Alternative 3
Regional Groundwater Development outside the Study Area

The Bill Williams Sub-basin and Big Sandy Sub-basin alternatives deliver water to the planning areas from the two separate groundwater basins. A conceptualized well field is assumed to be placed in the river bed alluvium and the total 2050 water supply deficit of 42,379[1] AFY of water delivered through a transmission line that follows along major roadways.

Alternative 3. Regional Groundwater Development outside the Study Area - Impacts assessed to watershed within study area

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	0/-	Assume imported water will be treated but concerns with greater mineral content from outside sources.
Impact to Streamflow	+	This alternative assumes import of the total 2050 projected water supply deficit. Benefits anticipated from a decreased need to utilize water supplies from within Study Area.
Impact to Groundwater Availability	+	Same
Biologic		
Impact to Vegetation	+	Same
Impact to Wildlife (Riparian-Obligate)	+	Same
Impact to Fish/Aquatic Species	+	Same
Watershed		
Impact to Watersheds	+	Same

[1] Water Supply deficit as calculated in Phase 1 Demand Analysis; Status Quo Method.

Alternative 4.1
Conversion of Existing Septic Systems (Urban)

This alternative proposes converting existing septic systems to sewer service resulting in increased availability of effluent for reuse and/or recharge, specifically in urban areas. For the purposes of this discussion only, urban areas are those serviced by a water provider.

Two "uses" of the additional effluent will be considered. Direct use will consist of irrigation that replaces a particular volume of an existing water source. Indirect use will include recharge into the groundwater system.

Each WPA has treatment facilities that produce different classes or quality of effluent from Class B to Class A+. The assumption is that any expansion of treatment facilities (Groups A & B) will continue with the same Class of water. However, there is an alternative or option to upgrade the treatment facility to improve the effluent quality. Also, the construction of a new treatment facility (Group C) will be Class A+ water.

It is assumed that an existing facility does not need added capacity until it has reached 80% design capacity. There are 3 categories or scenarios:

Group A – existing wastewater treatment facility can accommodate additional capacity

Group B – existing wastewater treatment facility will need to build additional capacity

Group C – a new wastewater treatment facility is required

Alternative 4.1. Conversion of Existing Septic Systems to Sewer System (Urban)

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	+	The assumption is that the treated effluent would either be reused or recharged; not discharged into a stream, so the location of recharge would dictate the level of effect if any on stream water quality. Treated effluent is typically better quality than septic tank leachate, so local water quality could also be improved from baseline due to removal of septic systems. Concerns with water quality and biologic impacts from emerging contaminants; many studies have shown a detrimental impact of ECs on fish, in very low concentrations. Sewering septic tanks should improve treatment levels and hence result in lower ECs in the effluent, BUT the end use may be changing (discharge points, depth to groundwater).

Impact to Streamflow	+	Reuse replaces part of the GW demand, which reduces capture of base flow. If treated water is recharged, additional GW is available to support base flow; recharge can be located to optimize this effect.
Impact to Groundwater Availability	+	Reuse replaces part of the GW demand, recharge augments GW availability.
Biologic		
Impact to Vegetation	0/+	Minimal, but could be positive if decreased GW demand due to reuse results in reduced GW level decline and if recharge facilities are located to optimize augmentation of streamflow and riparian groundwater levels.
Impact to Wildlife (Riparian-Obligate)	0/+	Same as above
Impact to Fish/Aquatic Species	+/-	The assumption is that the treated effluent would either be reused or recharged; not discharged into a stream, so the location of recharge would dictate the level of effect if any on stream water quality. Local water quality could be improved from baseline due to removal of septic systems. Fish/aquatic species could benefit from increased reuse (decreased GW demand=decreased capture) and streamflow augmentation from appropriately located and designed recharge facilities. Possible negative impact to water quality and fish/aquatic species depending on level of wastewater treatment and where effluent is recharged.
Watershed		
Impact to Watersheds	0	

Alternative 4.2
Conversion of Existing Septic Systems (Rural)

This alternative proposes converting existing septic systems to sewer service specifically in rural areas. For the purposes of this discussion, rural areas are those outside of a water provider service area and sewer service area.

The new or additional available effluent will only be of value if it reduces demand for another water supply or provides a new water supply. Two "uses" of the additional available effluent will be considered. Direct use will consist of irrigation that replaces a particular volume of an existing water source. Indirect use will include recharge into the groundwater system. The type of treatment and resulting cost will depend on the desired use. However, for this alternative, the cost estimate will be based on a facility that produces Class A+ effluent.

Alternative 4.2. Conversion of Existing Systems (Rural)

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	+	Eliminates poorly treated discharge from septic systems. Low density systems typically not quality concern although localized conditions may preexist (i.e. high groundwater, near aquatic resources). Concerns with water quality and biologic impacts from emerging contaminants; many studies have shown a detrimental impact of ECs on fish, in very low concentrations. Sewering septic tanks should improve treatment levels and hence result in lower ECs in the effluent, BUT the end use may be changing (discharge points, depth to groundwater).
Impact to Streamflow	0/+	Minimal due to low density. Reuse replaces part of GW demand, which reduces capture of base flow. If treated water is recharged, additional GW is available to support base flow; recharge can be located to optimize this effect.
Impact to Groundwater Availability	0/+	Minimal due to low density. However, large numbers of conversions and targeted recharge could have positive effects on groundwater.
Biologic		
Impact to Vegetation	0/+	Minimal due to low density. But could be positive if decreased GW demand due to reuse results in reduced GW level decline and if recharge facilities are located to optimize augmentation of

		streamflow and riparian GW levels.
Impact to Wildlife (Riparian-Obligate)	**0/+**	Same as above
Impact to Fish/Aquatic Species	**+/-**	The assumption is that the treated effluent would either be reused or recharged; not discharged into a stream, so location of recharge would dictate the level of effect if any on stream water quality. Local water quality could be improved from baseline due to removal of septic systems. Fish/aquatic species could benefit from increased reuse (decreased GW demand=decreased capture) and streamflow augmentation from appropriately located and designed recharge facilities. Possible negative impact to water quality and fish/aquatic species depending on level of wastewater treatment and where effluent is recharged.
Watershed		
Impact to Watersheds	**0**	

Alternative 5
Existing Unused Effluent and/or Capacity

Although most facilities in the study area do use effluent for some purpose, there are facilities where some or all the effluent is unused. For the purposes of this discussion unused effluent is defined as effluent that is passively disposed of. Effluent that is evaporated or discharged into a wash is considered unused. This alternative proposes utilizing effluent that is presently unused. Five WPAs currently have unused effluent: Cottonwood, Camp Verde, Clarkdale, Jerome and Sedona.

However, formal agreements to provide effluent to an area or body of water are interpreted as utilized. Big Park WPA is the only one instance of effluent being utilized because of a formal agreement. Big Park Domestic Wastewater Improvement District has an agreement with the Forest Service to discharge a particular volume of effluent down a tributary of Jack's Canyon Wash.

Two "uses" of the additional effluent will be considered. Direct use will consist of irrigation that replaces a particular volume of an existing water source. Indirect use will include recharge into the groundwater system. The type of treatment and resulting cost will depend on the desired use. For this alternative the cost estimate will be based on a facility that produces Class B with an option to upgrade to Class A+.

Alternative 5. Existing Unused Effluent and/or Capacity

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	0/-	Water quantity issues more of issue when removing effluent that currently supports perennial or aquatic habitats. However, concerns with water quality and biologic impacts from emerging contaminants; many studies have shown a detrimental impact of ECs on fish, in very low concentrations. Water quality is also a concern when treating for human uses. Assume that reuse/recharge of unused effluent may require a higher level of treatment.
Impact to Streamflow	-	Streams dependent upon effluent discharge to support flow/aquatic/riparian habitats may be impacted where use of effluent will instead be used to meet projected demands.
Impact to Groundwater Availability	+	Positive influence on water table, due to reduction in pumping demands - if this offsets future GW development

Biologic		
Impact to Vegetation	-	negative from potential loss of effluent currently discharged into drainage; positive where future pumping demands are reduced
Impact to Wildlife (Riparian-Obligate)	-	negative from loss of effluent currently discharged into drainage; positive where future pumping demands are reduced
Impact to Fish/Aquatic Species	-	negative from loss of effluent currently discharged into drainage; positive where future pumping demands are reduced
Watershed		
Impact to Watersheds	-	Impacts to stream habitats from reuse of effluent may negatively impact overall health and function of watersheds.

Alternative 6
New Effluent from New Population

This alternative estimates the volume of new effluent generated from new population in 2050. New population is the difference between the population in 2006 and 2050.

The volume of effluent generated from the new wastewater is presented as a range of possible values. The high estimate assumes that all new wastewater is captured in a sewer system for treatment, reuse and/or recharge. A more realistic volume takes into account the percentage of population in the region served by wastewater treatment facilities (WWTFs). In 2002 the Northern Arizona Council of Governments (NACOG) Section 208 Plan estimated that 45% of the population in Yavapai County was served by WWTFs. That percentage (45%) is utilized in this study for the conservative estimate. The two exceptions are Cottonwood at 60% and Prescott Valley at 100%.

Two "uses" of the additional effluent will be considered. Direct use will consist of irrigation that replaces a particular volume of an existing water source. Indirect use will include recharge into the groundwater supply. The amount of treatment and resulting cost will depend on the desired use.

Each Water Planning Area has treatment facilities that produce different classes or quality of effluent from Class B to Class A+. The assumption is that any expansion of treatment facilities (Groups A & B) will continue with the same Class of water. However, there is an alternative or option to upgrade the treatment facility to improve the effluent quality. Also, the construction of a new treatment facility (Group C) will be Class A+ water.

It is assumed that an existing facility does not need added capacity until it has reached 80% design capacity. There are 3 categories or scenarios:
Group A – existing wastewater treatment facility can accommodate additional capacity
Group B – existing wastewater treatment facility will need to build additional capacity
Group C – a new wastewater treatment facility is required

Alternative 6. New Effluent from New Population

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	**0/-**	Direct use of new effluent supplies, when considered solely is not anticipated to negatively impact environmental resources. Assume that reuse/recharge of unused effluent may require a higher level of treatment. Concerns with water quality from emerging contaminants, whether treating for human uses or

		using as mitigated/alternate sources for the environment.
Impact to Streamflow	+	Offsets some development of other water resources
Impact to Groundwater Availability	+	Could have benefit to groundwater availability because pumping could be reduced from new uses/volumes of effluent available. Impact to GW would be (+) if effluent is recharged.
Biologic		
Impact to Vegetation	+	Benefits anticipated from the offset of stream impacts from development of other uses. Likewise recharge benefits to groundwater could also benefit biologic and watershed conditions.
Impact to Wildlife (Riparian-Obligate)	+	Benefits anticipated from the offset of stream impacts from development of other uses. Likewise recharge benefits to groundwater could also benefit biologic and watershed conditions.
Impact to Fish/Aquatic Species	+	Benefits anticipated from the offset of stream impacts from development of other uses. Likewise recharge benefits to groundwater could also benefit biologic and watershed conditions.
Watershed		
Impact to Watersheds	+	Benefits anticipated from the offset of stream impacts from development of other uses. Likewise recharge benefits to groundwater could also benefit biologic and watershed conditions.

Alternative 7
Capture and Store Unappropriated Verde (or Tributary) Flood Water

This alternative proposes capturing unappropriated floodwater from the Verde River drainage area that is occasionally available when all downstream senior water rights are being satisfied and storage is being exceeded at SRP's reservoirs.

Four options to capture unappropriated floodwater were identified for evaluation increasing the height of Bartlett Dam, increasing the height of Horseshoe Dam, in-stream storage and off-stream storage. The options of increasing the height of the dams would require in-stream or off-stream storage in strategic locations upstream of the dams to capture and store water for distribution to the areas where it is needed.

Alternative 7. Capture and Store Verde (or Tributary) Flood Water

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	**0/-**	Addition of storage reservoirs (in-stream or off-stream) may impact water temperature, turbidity, siltation, and downstream effects.
Impact to Streamflow	**-**	The hydrologic regime would be altered from natural conditions by capturing and storing a portion of high flows, which removes that water from the stream. If its mainstem storage, negative impact would be larger, but tributary storage would also have negative impact.
Impact to Groundwater Availability	**0/+**	Localized benefit due to increased bank storage, and/or reduced pumping requirements. GW availability may improve due to infiltration of stored water.
Biologic		
Impact to Vegetation	**-**	Within area of conservation storage, vegetation will be impacted. Although some vegetation may be inundated by the storage, edges will develop a riparian zone that may offset some impacts to areas of inundation. However, creation of edge habitat surrounding a reservoir (vs. native stream system) may increase conditions for establishment of non-native vegetation. Recruitment and survival of riparian vegetation is linked to high flows; removal of a portion of those flows could have a negative impact.

Impact to Wildlife (Riparian-Obligate)	-	Removal of a portion of the high flows would negatively impact recruitment and survival of riparian vegetation and hence would impact the species that nest, forage, and otherwise utilize that habitat for all or portions of their life cycles. Impacts to ESA species or designated/proposed critical habitat could require increased regulatory compliance.
Impact to Fish/Aquatic Species	-	Storage/reservoir conditions may favor non-native species expansion. High flows are an important part of the streamflow regime and do much geomorphological work, which contributes to maintaining riparian and aquatic conditions in many ways. High flows and maintenance of riffle conditions are an important function in many aquatic species reproductive cycle. Removal of a portion of the high flow regime could impact ecological response in ways that would require considerable study to fully delineate.
Watershed		
Impact to Watersheds	-/0	Dependent upon placement of capture reservoirs within watershed, downstream impacts of hydrologic and biologic function could be anticipated. Overall watershed function may be altered from the upstream placement of reservoirs.

Alternative 8 Storm Water –Macro Water Harvesting

The general water harvesting concept represented by this alternative involves capturing precipitation before it enters surface water channels and recharging it into the regional aquifer or utilizing it locally.

This water harvesting alternative includes the concept of capturing water that would otherwise evaporate. The term "Macro-Rainwater Harvesting" refers to rainwater harvesting on a larger scale. In this alternative, we consider two general categories of macro-rainwater water harvesting activities:

8.1 Rainwater harvested from developed areas
8.2 Rainwater harvested from undeveloped areas

8.1 Rainwater Harvested from Developed Areas

The concept of this category is to take water captured from developed areas and convey it to optimal recharge areas or to be used for on-site irrigation. Harvested water in residential and commercial areas would originate from impermeable surfaces such as rooftops, driveways, parking lots, sidewalks and roads. Precipitation could be captured by using surface or sub-surface methods. Any one particular developed property may be a relatively small area but the accumulation of many developed properties could be relatively large in area.

One example that has been quantified is the potential water captured from roof-tops during average rainfall events and storing it in cisterns or barrels and using it in close proximity to where it was captured. It was done for all building roof-tops, buildings 50,000 sq. ft or more, 100,000 sq. ft or more and residential buildings.

Alternative 8.1. Rainwater Harvested from Developed Areas

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	0/-	The quality of water in cisterns is likely to vary significantly and there could be health issues. Community cisterns may fair better, but water quality may still be an issue. Overall affect to environmental resources may be minimal, considering outside/landscape uses.
Impact to Streamflow	0/+	Depends on quantity of urban water capture/use. Anticipate that less water pumped from aquifer, benefiting streamflow. Runoff & recharge transpiration could be affected, and should be evaluated in further review.

Impact to Groundwater Availability	+	Anticipated benefit from reduced need to utilize water supplies (GW/SW) for landscape/outside purposes.
Biologic		
Impact to Vegetation	+	Less water pumped
Impact to Wildlife (Riparian-Obligate)	+	Less water pumped
Impact to Fish/Aquatic Species	+	Less water pumped
Watershed		
Impact to Watersheds	+	Less water pumped

8.2. Rainwater Harvested from Undeveloped Areas

Macro-rainwater harvesting from undeveloped areas include concepts such as subsurface capture, land surface treatment and vegetation treatment. All of the above concepts are based on the premise that ultimately, these flows, if not harvested, would be subject to evaporation and/or evapotranspiration.

The general concept behind subsurface capture is to collect water from shallow saturated soils via underground systems prior to evaporation caused by capillary action in finer soils. Capillary action and subsequent evaporation of saturated soils can take place within 1-1.5 meters of surface soils.

Land surface treatment involves concepts such as compaction of land, re-grading of land, or material application to lands to create conditions of increased runoff from storm events.

Vegetation treatment as envisioned in this alternative is mostly vegetation management and includes concepts such as forest thinning, fire utilization, juniper removal, etc. It is intended to reduce ET and create conditions where some of the water recharges the aquifer through natural processes.

8.2. Rainwater Harvested from Undeveloped Areas

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	+/-	Concentrated constituents could be captured and treated to avoid surface water or GW contamination. Impact may be negative since treatment is uncertain and could differ from place to place.

Impact to Streamflow	**+/-**	Under above definition, use of captured water could reduce pumping and/or surface water diversion. However, it's unlikely that there are areas where sheet flow makes zero contribution to vegetation, surface water or infiltration. For example, except for the component of rainfall that lands directly in gullies, the rainwater that gets into gullies gets there via sheet flow.
Impact to Groundwater Availability	**+/-**	Same as above - increase water table
Biologic		
Impact to Vegetation	**-**	May cause non-native proliferation in disturbed areas.
Impact to Wildlife (Riparian-Obligate)	**-**	More evidence required to understand direct or indirect impacts to riparian-obligate wildlife species.
Impact to Fish/Aquatic Species	**-**	More evidence required to understand direct or indirect impacts to Fish/Aquatic wildlife species.
Watershed		
Impact to Watersheds	**-**	Changing micro-climate affecting soil, vegetation and attributes of landscape, can impact plants and animals through disturbed trophic-level interactions.

Alternative 9 Conservation

This alternative proposes to improve water efficiency which is the simplest, most effective way of conserving water. Conservation programs such as high efficiency toilets, xeriscaping, hot water recirulation, waterless urinals, rainwater harvesting, public ordinances for new development and public education are just some of the programs that can be implemented.

Conservation measures were built in to the Phase I Demand Analysis portion of the Appraisal Report by providing the opportunity for each of the individual WPAs to reduce their GPCD rate in 2050. However, there were no common guidelines for the reduction and the lowering of the GPCD rates were done inconsistently. It is difficult to give an overall average of how much additional future water this alternative could conserve since the WPAs' reduction of their 2050 GPCD rates were more drastic in some than others.

Alternative 9. Conservation

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	+	Less water pumped
Impact to Streamflow	+	Less water pumped
Impact to Groundwater Availability	+	Less water pumped
Biologic		
Impact to Vegetation	+	Less water pumped
Impact to Wildlife (Riparian-Obligate)	+	Less water pumped
Impact to Fish/Aquatic Species	+	Less water pumped
Watershed		
Impact to Watersheds	+	Less water pumped

Alternative 10 & 11 Surface Water Outside the Study Area
Alamo Lake & Colorado River via Diamond Creek, Lake Mead, Lake Havasu, Lake Mohave, Lake Powell

Both of these alternatives propose delivering the total 2050 water supply deficit of 42,379[2] AFY of surface water from outside the study area.
The alternatives are as follows:

Alternative 10 (Alamo Lake Pipeline Alignment) delivers water through a transmission line that follows along major roadways to the planning areas from Alamo Lake.

Alternative 11 (Colorado River Pipeline Alignments) deliver water through transmission lines that follow along major roadways to the planning areas from the Colorado River via Alamo Lake, Lake Havasu, Lake Mead, Lake Mohave, Diamond Creek, and Lake Powell.

The alternative from Colorado River via Alamo Lake will be similar to the Alamo lake alternative but with a water exchange component. It consists of acquiring a Colorado River water entitlement withdrawn as an exchange from Alamo Lake. The infrastructure and alignment would be the same as the Alamo Lake alternative.

Alternative 10. Surface Water Outside the Study Area; Alamo Lake - Issues assessed WITHIN study area from importation from Alamo Lake

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	0	Assumes lake water will be treated to potable standards
Impact to Streamflow	+	Use less GW
Impact to Groundwater Availability	+	Use less GW
Biologic		
Impact to Vegetation	+	Proportional to volume imported
Impact to Wildlife (Riparian-Obligate)	+	Proportional to volume imported
Impact to Fish/Aquatic Species	+	Proportional to volume imported
Watershed		
Impact to Watersheds	+	Proportional to volume imported

[2] Water Supply deficit as calculated in Phase 1 Demand Analysis; Status Quo Method.

Alternative 11. Surface Water Outside the Study Area; Colorado River via Alamo Lake, Lake Havasu, Lake Mead, Lake Mohave, Diamond Creek, and Lake Powell - Issues assessed from WITHIN study area from importation of water from Colorado River

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	0/-	Assume imported water will be treated but concerns with greater mineral content
Impact to Streamflow	+	Use less GW
Impact to Groundwater Availability	+	Use less GW
Biologic		
Impact to Vegetation	+	Proportional to volume imported
Impact to Wildlife (Riparian-Obligate)	+	Proportional to volume imported
Impact to Fish/Aquatic Species	+	Proportional to volume imported
Watershed		Proportional to volume imported
Impact to Watersheds	+	Proportional to volume imported

Alternative 12
Weather Modification

This alternative proposes to look at weather modification by cloud seeding for producing additional water. The process introduces particles such as silver iodide compounds into moist air as it moves up to higher elevation. The moisture in the air cools and condenses around the particles forming orographic clouds and then falls as snow or rain. Modeling studies have indicated moderate potential for precipitation and stream flow enhancement by wintertime cloud seeding over the Mogollon Rim with increases in yield varying from 11.1 to 23.6 percent.

Alternative 12. Weather Modification

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	0/-	Could increase turbidity during flood event. Maybe rainfall constituent concerns with this alternative. Similar to concerns about emerging contaminants.
Impact to Streamflow	0/+	If designed and implemented properly, could increase stream flow up to 10-15 %
Impact to Groundwater Availability	0/+	Potential to increase recharge - timing is very important
Biologic		
Impact to Vegetation	+	Increasing precipitation into study area could benefit hydrologic, biologic and watershed resources. However additional definition would be required to determine how augmentation efforts would be focused; temporally and spatially.
Impact to Wildlife (Riparian-Obligate)	+	Increasing precipitation into study area could benefit hydrologic, biologic and watershed resources. However additional definition would be required to determine how augmentation efforts would be focused; temporally and spatially.
Impact to Fish/Aquatic Species	+	Increasing precipitation into study area could benefit hydrologic, biologic and watershed resources. However additional definition would be required to determine how augmentation efforts would be focused; temporally and spatially.
Watershed		
Impact to Watersheds	+	Increasing precipitation into study area could benefit hydrologic, biologic and watershed resources. However additional definition would be required to determine how augmentation efforts would be focused; temporally & spatially.

Alternative 13
Watershed Management

This alternative proposes to increase water yield by manipulating vegetative coverage specifically in watersheds with chaparral shrublands, ponderosa and conifer forests. Results for water yield are best in areas that receive more than 19 inches of annual precipitation or more. However, clearing vegetation for augmenting water supplies may be short lived due to quick re-growth, maintenance costs, water quality degradation, flooding and concerns over environmental impacts.

Alternative 13. Watershed Management

Environmental Issues	(+) or (-) Affect, or Minimal (0)	Notes
Hydrologic		
Impact to Water Quality	-	Alternative description states that "*Removing trees for water yield can cause degraded water quality…*". Also chaparral studies show that following treatments there was an initial flush of both sediment and nutrients that lasted for a year or two.
Impact to Streamflow	+	It is estimated that runoff may increase from watershed and vegetation treatment. NAU has estimated a range of runoff increases; from 7 to 21% in first treatment areas. This estimate is based on Beaver Creek studies when basal area of ponderosa pine forest was reduced by 30-100%. The range estimated is intended to reflect the low and high end of a range of potentially expected values. As such, the low end is adjusted downward for diminishing effects over time, with no increased water yield after 6 years for a given treatment. The high end reflects the absolute possible high, the first year after treatment. There is anticipated to be diminishing returns over time after initial treatment. As part of the Four Forest Restoration Initiative a paired watershed study is planned to test water yield effects over time from various treatment intensities as well as effects of followup treatments.
Impact to Groundwater Availability	+	Groundwater recharge should increase with better upland watershed vegetation management
Biologic		

Impact to Vegetation	+	Improvements due to increased water availability and more natural hydrologic regime than in over forested watershed
Impact to Wildlife (Riparian-Obligate)	+	
Impact to Fish/Aquatic Species	+	
Watershed		
Impact to Watersheds	+	Overall improved watershed condition from thinning/burning, reduced risk of catastrophic wildfire